Ph.D. Synopsis on

"Studies on Chemically Deposited 'Indium' (In) Doped $Cd_{1-x}Zn_xSe$ Thin Films for Photoelectrochemical Solar Cell"

Submitted to

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Physics

Format for Submission of Ph.D. Synopsis /Work plan

Abstract of proposed work plan / Problem:

"Studies on Chemically Deposited 'Indium' (In) Doped $Cd_{1-x}Zn_xSe$ Thin Films for Photoelectrochemical Solar Cell"

1. Introduction:-

Increasing world population and demands of utilization of natural resources causes serious problems of energy crises in near future. The sun is the ultimate biggest source of energy holding key to resolve the energy crises arising out of growing rift between our energy consumption and production. The solar energy has greatest potential of all the sources of renewable energy. The conversion of solar energy into usable form is potential challenge to the scientists.

In the past few years, II-IV semiconductors thin films have attracted considerable attention from the research community because of their wide range of applications in the fabrication of solar cells and other electronic and opto-electronics devices. In the architecture of photo voltaic devices, the cadmium Sulphide (CdS) was mostly used as a window layer. [1-2]

Cadmium zinc Selenide ($Cd_{1-x}Zn_xSe$) has properties in between CdSe and ZnSe. Addition of Zn to the most widely used CdSe buffer layer material enhances various important properties like electronic, electrical, optical properties of devices. It has been widely used as a wide band gap window material in hetro-junction solar cells and photoconductive devices. [3-5].

$Cd_{1-x}Zn_xSe$ II-VI ternary semiconductor compound can form a continuous series of solid solution allowing systematic variation of the band gap from 1.74 eV for CdSe (both for hex. and sphalerite) at 25 °C (77 °F) to 2.70 eV at 25 °C (77 °F) for ZnSe by adjusting the composition. The addition of Zn to widely used CdS window material improves the electrical and optical properties of the devices. [6-10]

To the best of our knowledge, very few reports that have been focused the In doped $Cd_{1-x}Zn_xSe$ using a cost effective chemical technique for Photoelectrochemical properties.

Preparation of good quality In doped $Cd_{1-x}Zn_xSe$ thin films

It is proposed to synthesize $Cd_{1-x}Zn_xSe$ thin films by chemical method (chemical bath deposition / spray Pyrolysis). Initially the good quality $Cd_{1-x}Zn_xSe$ thin films will be deposited on glass and conducting glass substrates. The various preparative parameters like concentration of the ingredients, deposition temperature, thickness and other parameters will be optimized to get good quality $Cd_{1-x}Zn_xSe$ thin films. The as deposited thin films will be characterized by various characterization techniques in the following manner. The good composition will be doped by In

[A] Structural Analysis:

An X-ray diffraction technique will be employed to know the structural changes as a result of Zn incorporation into CdSe. The interplanar distance (d), intensities of reflections, lattice constants and crystal dimension will be examined and their dependence on composition will be studied.

[B] Compositional Analysis:

The compositional analysis will be done by means of an EDAX or EDS technique and correlation will be made with as taken and observed contents of Cd, Zn, Se elements.

[C] Microscopic Studies:

To study the surface morphological features SEM/TEM technique will be utilized. The crystallographic and morphological information will be used to explain the transport mechanism and optical properties.

[D] Optical Properties:

The optical constants viz optical absorption coefficient (α), the energy band gap (E_g) and mode of optical transition will be determined from optical studies. For this purpose optical

absorption / transmission / reflection spectra of the as deposited $Cd_{1-x}Zn_xSe$ series will be studied.

[E] Electrical transport properties:

The electrical conductivity and thermo-electric power will be measured of all these as deposited thin films. Various terms like carrier concentration (n), mobility (μ), activation energy (E_a) and barrier height (ϕ_B) will be determined.

[F] Photoelectrochemical studies:

Photoelectrochemical studies will be under taken by forming a cell composed of these as deposited film electrode as active photo electrode and a suitable electrolyte. The various cell characteristics under dark and under illumination will be studied to examine the various cell parameters such as short circuit current (I_{sc}), open circuit voltage (V_{oc}), series resistance (R_s), shunt resistance (R_{sh}) flat band potential (V_{fb}) and power output will be determined. An optimum composition yielding better performance will be searched out and its correlation with observed film properties will be studied.

[G] Effect of technical parameter:

To boost the cell performance effect of technical parameter such as material thickness / heat treatment / impurity concentration will be undertaken.

2. Review of Literature and Development in the subject

In recent years, considerable interest has been shown in the synthesis and Photoelectrochemical properties of semiconductor thin films. CdSe belongs to the II–VI group and is n-type in nature [11]. Electron–hole pairs generated in CdSe are well separated with electrons being highly localized [12-13]. So it is the most studied nanocrystalline semiconductor as a photoanode in Photoelectrochemical (PEC) solar cells because of its suitable band gap, long lifetimes, and important optical properties, excellent stability, easy fabrication and numerous device applications.

Cadmium Selenide is a promising new material belonging to IV-VI group for use in photovoltaic solar cells. With a direct energy band gap of about 2.45 eV, and a high optical

absorption coefficient, only a few microns of SnS are needed to absorb most of the incident light [14-21].

In the past, the thin films of CdSe and ZnSe have been studied by several researchers, depositing the films using techniques such as vacuum evaporation, spray pyrolysis, chemical bath deposition and electrochemical deposition to prepare ZnSe films. Among methods above, chemical deposition is particularly important because of its simplicity, low cost and simple facility to obtain large area films.

3. Objectives of Research/Proposed Hypothesis

Following are the objectives of our research work

1. To deposit good quality In doped $Cd_{1-x}Zn_xSe$ (x = 0 to 1) thin films by chemical route.
2. To study various properties such as thickness, optical, electrical properties of as deposited samples.
3. To study micro-structural and morphological features of as grown In doped $Cd_{1-x}Zn_xSe$ thin films.
4. To use these films in Photoelectrochemical solar cells and study their characteristics.
5. To study the effect of technical parameter on solar cell performance of optimum samples of In doped $Cd_{1-x}Zn_xSe$.

4. Methodology to be adopted:

The chemical method will be used to synthesize the $Cd_{1-x}Zn_xSe$ thin films. Unlike the physical methods of preparation of thin films involving evaporation or ejection of material from a source, chemical methods of thin film deposition entail a definite chemical reaction. The chemical method is presently attracting considerable attention as it does not require sophisticated instrumentation like vacuum system and other expensive equipments. The starting chemicals are commonly available and cheap. The preparative parameters are easily controllable and better orientations and improved grain structure can be obtained.

In our present work, In doped $Cd_{1-x}Zn_xSe$ thin films will be prepared by a chemical method. The deposited thin films will be characterized to study the structural, morphological, optical and electrical properties by means of XRD, SEM, UV-Vis spectrophotometer

respectively. with the help of preparative parameters. The Photoelectrochemical solar cell properties of In doped $Cd_{1-x}Zn_xSe$ thin films will be studied.

5. Importance of study / Society applications:

Since then a large number of metal as well as mixed chalcogenide and oxides have been used as photoelectrode in PEC cells. The stability and efficiency of PEC cells are mainly dependent on preparation conditions for photoelectrode, electrolyte and experimental conditions set during the experiment [21]. Determination of electronic parameters of these semiconducting thin films is essential in testing their suitability. The basic requirements of good thin film photoelectrode for PEC cells are low resistivity and larger grain size. Large grain size leads to reduction of grain boundary area of the thin film leading to an efficient energy conversion. The low resistivity of the photoelectrode required to minimize the series resistance of the PEC cell which leads to lower the short circuit current [22-24]. In PEC cells, the use is made of the interface which is formed on merely dipping the semiconductor into electrolyte solution and liquid junction potential barrier can be easily set up. Polycrystalline semiconductor film can be used without any drastic decrease in efficiency. This is because of the intimate and perfect contact of liquid electrolyte within crystalline grains. Thus PEC cell provide an economical chemical route for trapping solar cells. It consists of a photosensitive n-or-p- type semiconductor electrode and a counter electrode dipped in a suitable electrolyte. Binary and ternary chalcogenide semiconductors of II–VI have received widespread interest in the field of PEC. Single crystals as well as polycrystalline thin films are giving good response.

For the efficient optoelectronic device application, material is usually CdS in which very high sensitivity is possible as compared to CdSe in which lower sensitivity has been observed. Considering the advantages laid down by the binary CdS thin films, we focus our work to investigate the electrical and optical properties of CdS thin films in order to improve the performance of the devices and also finding new applications.

Another important advantage of using these materials in their binary and ternary forms is that they are capable of being formed as this film by various methods and at low cost. This material, in its thin film form has received a considerable attention in optoelectronic device and top layer as solar cell. The Photoelectrochemical cells are one of the most promising

semiconductor/ liquid junction solar cells. As solar energy is one of the promising energy sources for the future, a large number of researchers have concentrated on this aspect and a keen attention is required in this regard. A variety of electrochemical photovoltaic cells have been fabricated and investigated to convert the solar energy into electrical energy.

6. Proposed work Plan / Formulation and Structure of Study:

Year-wise plan of work and targets to be achieved

Year I-Plan:

In the first year of the research literature survey and data collection will be done in order to get more information about work already done and scope of the present work. The literature survey includes collection of Journals, books, and related research papers. The chemicals of high purity will be purchased and efforts will be made to deposit good quality $Cd_{1-x}Zn_xSe$ thin films. At the end of the year two progress reports will be submitted.

Year II-Plan:

In second year, all preparative parameters will be optimized in order to get good quality thin films of In doped $Cd_{1-x}Zn_xSe$ on conducting glass substrates. The as deposited films will be characterized by various characterizing techniques such as X-ray diffraction (XRD), Scanning Electron Microscopy (SEM), Energy Dispersive Analysis by X-ray (EDAX), UV-Vis photo spectrometer and photo electrochemical solar cell study. The results will be analyzed and efforts will be made to publish two or more research papers in reputed research journals. Two progress reports will be submitted at the end of this year.

Year III-Plan:

In the last year, an optimum composition yielding better result will be searched out and effect of technical parameter such as material thickness / heat treatment / impurity concentration will be studied. The results obtained will be analyzed and an attempt will be made to publish it in the reputed journals. Also efforts will be made to share results in the national and international Seminars, Conferences and Workshops etc. during this year. At the end of the year other progress reports will be submitted.

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